United States Patent [19]

Carroll, Jr. et al.

[11] **3,854,145**

[45] **Dec. 10, 1974**

[54] **STRIP-CHART RECORDING APPARATUS**

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[73] Assignee: **The Foxboro Company**, Foxboro, Mass.

[22] Filed: **Nov. 28, 1973**

[21] Appl. No.: **419,754**

[52] **U.S. Cl.** **346/116**, 346/136

[51] **Int. Cl.** **G01d 15/30**

[58] **Field of Search** 346/116, 117, 136, 68

[56] **References Cited**

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1,038,297	9/1912	Clawson	346/140 X
2,446,400	8/1948	Woolley	346/136 X
3,080,561	3/1963	Bowditch et al.	346/116

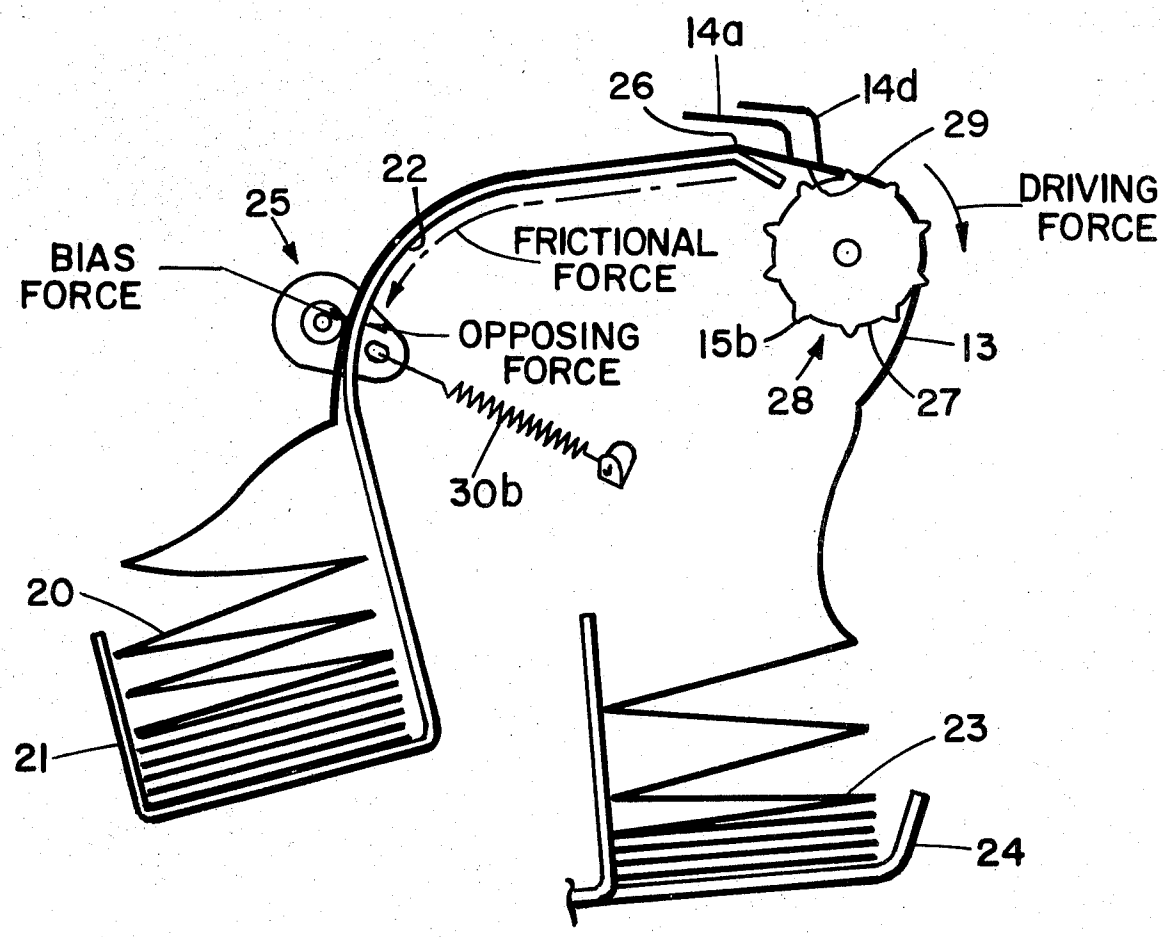
Primary Examiner—Joseph W. Hartary

Attorney, Agent, or Firm—Frank J. Fleming

[57] **ABSTRACT**

A strip chart recording apparatus for recording the value of a condition adapted for using compactly folded strip-chart stacks with provision to suspend the section of the strip-chart on which the recording is made under sufficient tension to maintain it substantially flat.

5 Claims, 7 Drawing Figures



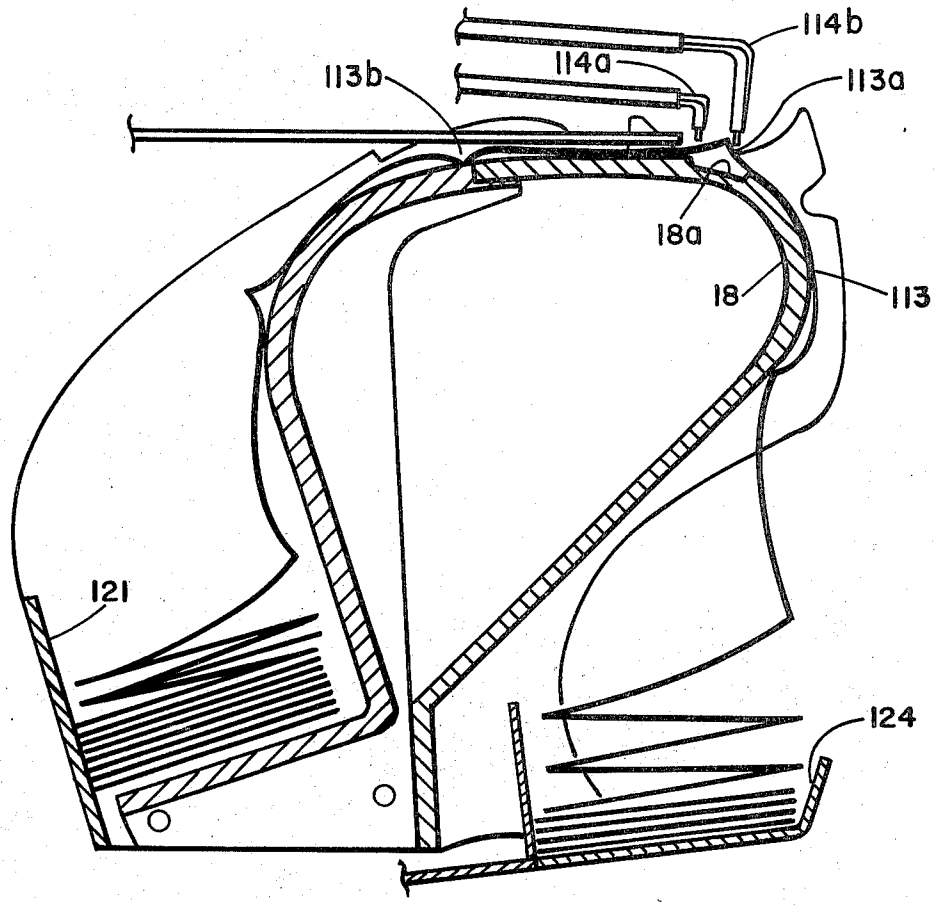


FIG. 1a

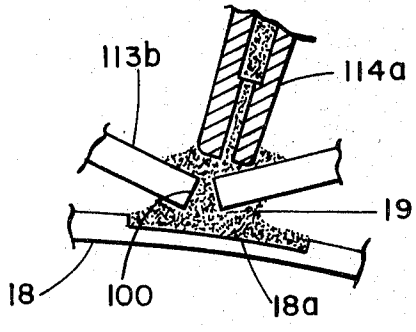


FIG. 1b

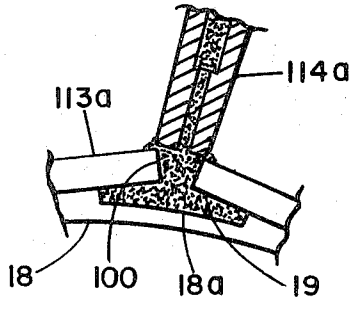


FIG. 1c

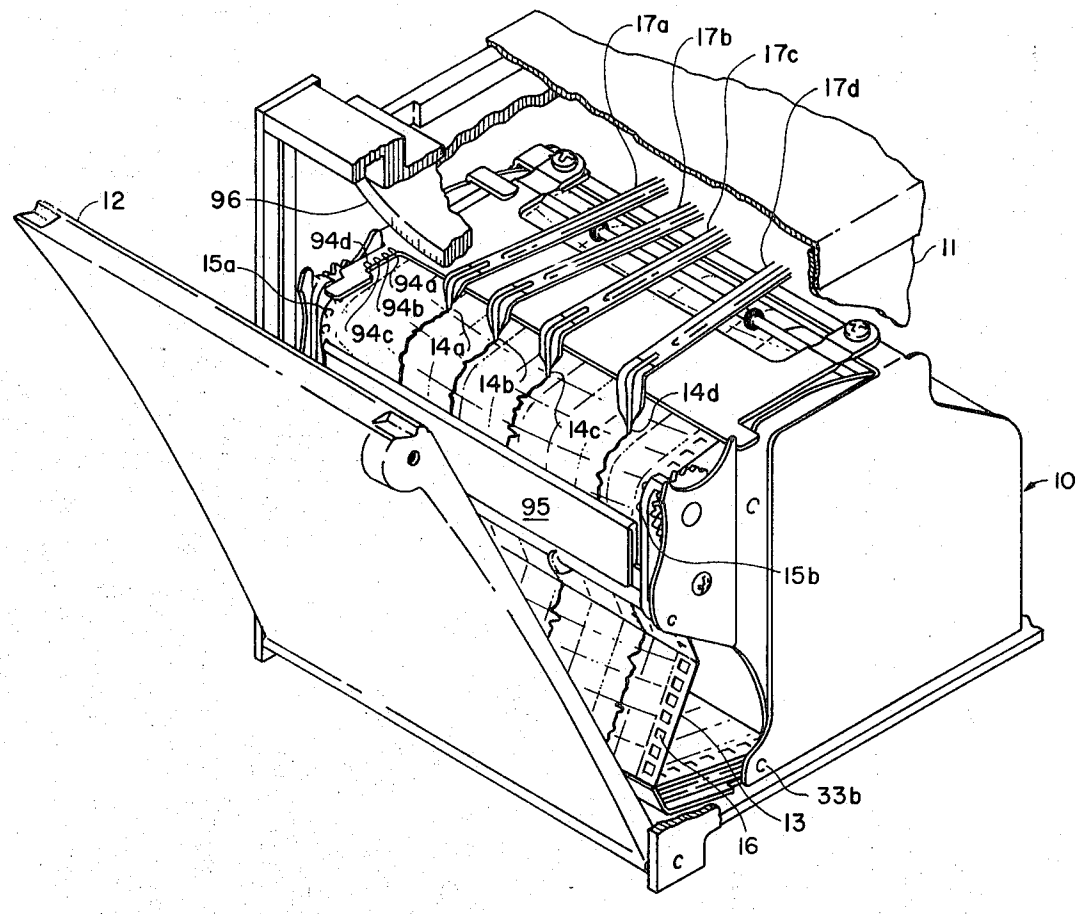

17a
17b
17c
17d
12
96
94d
15a
94a
94b
94c
14a
14b
14c
14d
11
10
95
15b
33b
13
16

FIG. 2

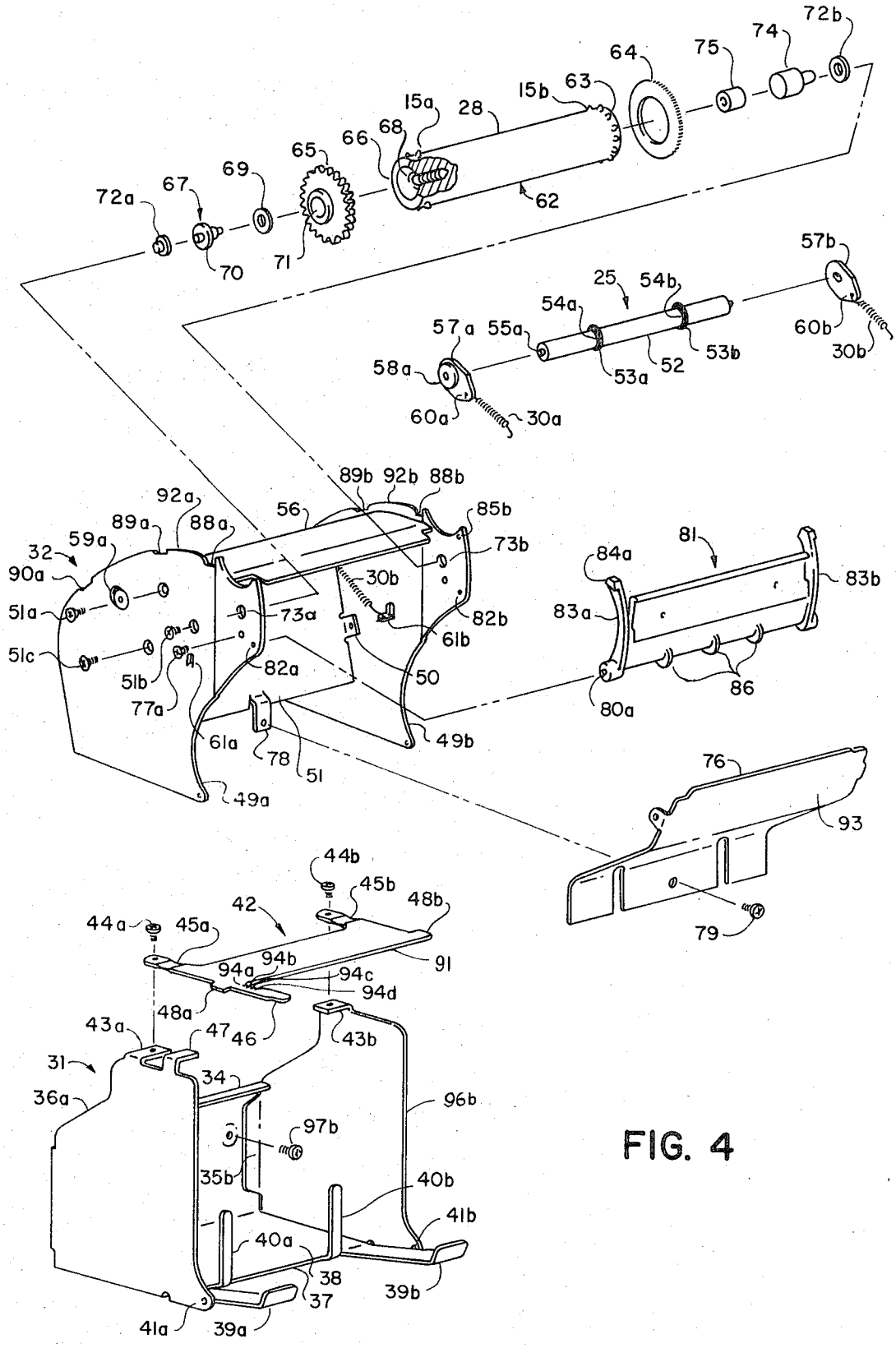

72b
74
75
64
63
15b
28
15a
68
66
65
69
67
72a
62
71
70
57b
25
54b
54a
57a
55a
60b
30b
58a
53b
52
53a
60a
30a
89b
92b
88b
92a
56
85b
89a
88a
59a
32
73b
90a
30b
84a
81
83b
51a
73a
82b
83a
61b
51c
82a
50
51b
77a
86
80a
61a
78
51
49b
49a
76
93
79
44b
45b
48b
42
44a
45a
91
94a
94b
94c
94d
48a
43a
47
46
43b
31
34
36a
96b
97b
35b
40b
41b
40a
38
37
39b
41a
39a

FIG. 4

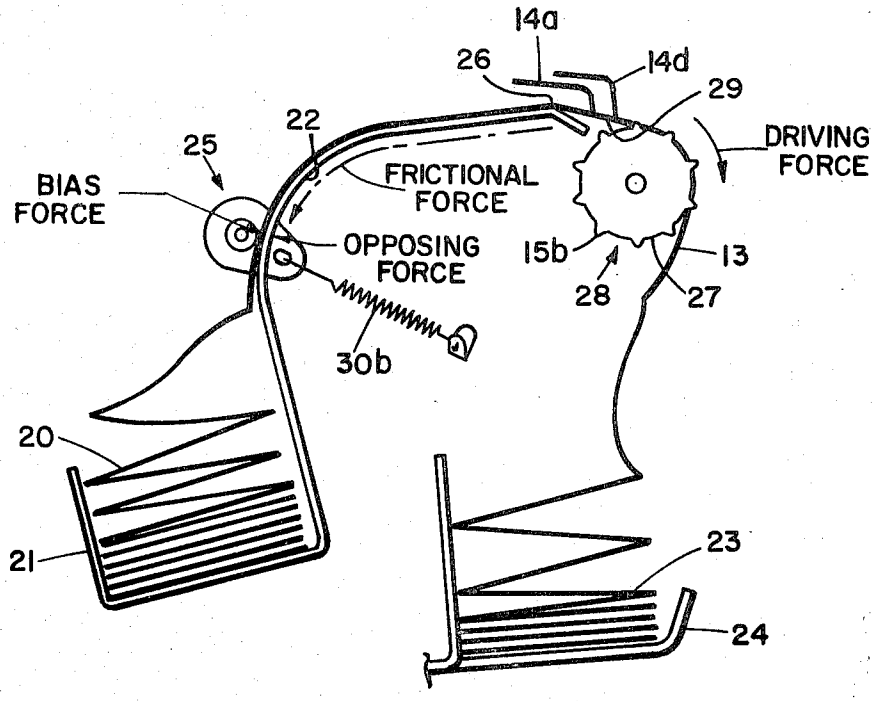

14a
26
14d
29
22
25
DRIVING FORCE
BIAS FORCE
FRICTIONAL FORCE
OPPOSING FORCE
15b
13
28
27
30b
20
21
23
24

FIG. 3

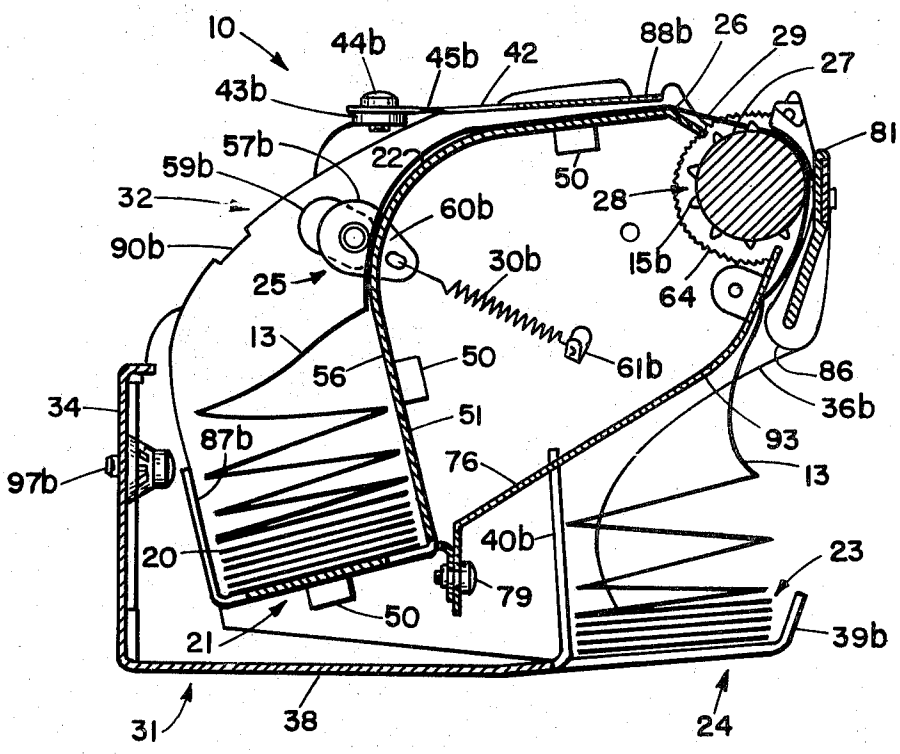

10
44b
45b
42
88b
26
29
27
43b
81
57b
22
50
59b
28
32
60b
90b
30b
15b
25
64
13
56
50
61b
86
34
51
36b
87b
93
97b
76
13
40b
20
23
79
50
21
39b
31
38
24

FIG. 5

STRIP-CHART RECORDING APPARATUS

FIELD OF THE INVENTION

This invention relates to improvements in strip-chart recording apparatus for recording the value of a condition. This invention is more particularly related to improvements in the chart drive unit such as recorders which use compactly folded strip-chart stacks.

DESCRIPTION OF THE PRIOR ART

In the prior strip-chart recording apparatus disclosed in Bowditch et al. U.S. Pat. No. 3,080,561, the strip-charts failed to assume a sufficiently flat condition at the folds for proper recording. Bowditch et al. only partially solved the problem of recording on strip-charts having transverse perforated folds. The invention disclosed and claimed in the present application solves these problems by means not taught by Bowditch et al.

SUMMARY OF THE INVENTION

The strip-chart recording apparatus disclosed in the above cited Bowditch et al. patent has enjoyed considerable commercial success. However, several difficulties have been experienced in the operation of these apparatus. These difficulties can best be understood by pointing out that the charts used on these apparatus are made of tissue thin paper 0.002 inch or less in thickness and 4 ½ inches wide. The charts are perforated by a series of cuts across the chart with only 72 tabs 0.020 inch wide of uncut paper remaining in the width of the chart. The charts are folded accordian fashion at the line of the perforations so that the remaining tabs of uncut paper are bent substantially 180°. In the Bowditch et al. apparatus, the chart remained partially bent as it was drawn over the groove in the platen so that the folded sections present alternately a *v* ridge and a *v* valley in the chart at the point of contact with the pen. These *v* ridges and *v* valleys caused a number of operating problems.

As the pen reached the peak of a *v* ridge, it frequently caught in a perforation and caused the chart to tear and at times stop. As the pen climbed or decended the *v* ridge or *v* valley, the attitude of the chart with respect to the pen tip changed materially. This resulted in such problems as a skipping where no record was made or flooding so the record was too smeared to be accurately read. As a *v* valley passed over the groove in the platen, it might touch the bottom thereof and cause the capillary formed between the chart and bottom surface of the groove to draw the ink through the perforation and thus smear the back of the chart. In a multiple pen recording apparatus, the flooding has been known to cause the ink to be syphoned out of one pen into the other, thus making it impossible to identify a record by its color. Another problem has been that the mismatch between the attitude of chart with respect to the pen reduced the continuity of the capillary lift of the ink from the pen reservoir sufficiently so as to limit the angle at which apparatus could be mounted because of the resulting increase in the height of the pen above the ink reservoir.

Accordingly, it is an object of this invention to provide strip-chart recording apparatus that is superior to such apparatus provided heretofore. It is a further object of this invention to provide an improved recording apparatus which eliminates the foregoing disadvantages experienced in the prior commerical apparatus.

The present invention overcomes the foregoing disadvantages by locating the pen so that it records on a suspended section of the strip-chart which is under sufficient tension to draw it into a substantially flat condition. The tension is sufficient to eliminate the *v* ridges and *v* grooves without being great enough to tear the strip-chart apart at its perforations. In this manner, the strip-chart is held flat enough so that it is maintained at the proper attitude with respect to the tip of the pen for continuous legible recording. The strip-chart is drawn evenly from the compactly folded stack over a convex surface by the sprocket teeth on each end of a chart roll driven at a constant speed which engage in the equally spaced perforations located on each side of the recording section of the strip-chart. At one end of the convex surface, a tensioning device presses the chart against the surface. The chart roll is spaced a sufficient distance from the other end of the convex surface so that a section of the strip chart is suspended without support. The length of the suspended section of the strip-chart is sufficient for several pens to inscribe records thereon. Inasmuch as the recording is done on the suspended section of the strip chart, there is no underlying platen surface for the strip-chart to form a capillary that would draw the ink through the perforations to smear the back of the strip chart.

DESCRIPTION OF THE DRAWINGS

The objects and advantages of this invention will be more fully understood from the description taken in connection with the accompanying drawings, wherein:

FIG. **1***a* is a cross-section of a prior art chart drive unit;

FIG. **1***b* is a cross-section of an enlarged view of the strip-chart of FIG. **1***a* showing a v-ridge over the groove in the platen;

FIG. **1***c* is a cross-section of an enlarged view of the strip-chart of FIG. **1***a* showing a v-valley over the groove in the platen;

FIG. **2** is a perspective view of a strip-chart recording apparatus constructed in accordance with the present invention;

FIG. **3** is a diagram showing the principle of the invention;

FIG. **4** is an exploded view of the chart drive mechanism, and

FIG. **5** is a cross-section of the chart drive mechanism with a side plate removed.

DESCRIPTION OF PREFERRED EMBODIMENTS

In order to appreciate the advance in the art represented by the present invention, a brief discussion of the prior apparatus is presented herein with reference to FIGS. **1***a*, **1***b*, and **1***c*. The strip-chart **113** is drawn (by means not shown) from the supply basket **121** over a platen **18** and deposited in receiving basket **124** with no tension applied to the strip-chart except for the weight of the chart against the surface of platen **18.** A groove **18***a* in platen **18** is located directly beneath the point at which pens **114***a* and **114***b* inscribe data on the strip chart **113.** With no tension the chart remains partially folded, resulting in presenting alternately v-ridges **113***a* and v-valleys **113***b* at the point the chart is contacted by the pens **114***a* and **114***b* and materially

changing the attitude of the pen tips with respect to the surface of the chart. At each fold, the ink, generally shown at **19**, enters the perforations **100**. At a v-valley **113***b*, the chart may contact the bottom of the groove **18***a* to form a capillary which draws the ink through the perforation and results in a smear on the back of the chart. At a v-ridge **113***a*, the spacing of the chart from the bottom of the groove **18***a* may be sufficient to prevent smears. However, there is danger that the pen will pierce the perforation, resulting in either tearing the chart or overcoming the friction of the clutch of the drive means (not shown) and stopping the chart. Other faults resulting from the change in the attitude of the pen with respect to the chart have been discussed earlier herein and need not now be reviewed.

Now referring to FIG. **2**, the chart drive unit **10** of the strip-chart recording apparatus is shown mounted in a cut-away section of an instrument case **11** with the door **12** partially open. The strip-chart **13** extends horizontally along the top of chart drive unit **10** and is drawn towards the front and beneath one or more recording pens **14***a*–14d by sprocket teeth **15***a* and **15***b*, which engage in a corresponding series of sprocket holes **16** in each side of the chart **13**. The pens **14***a*–**14***d* are suitably carried on the ends of pen arms **17***a*–**17***d* which are pivoted at their remote ends (by the usual means not shown herein) to permit the pens to be shifted transversely across the surface of the strip chart to trace measurement data thereon.

In accordance with the present invention, however, the ink smears, piercing and other problems, are eliminated by the unique suspension of the chart under tension at the point at which the record is made. Referring to FIG. **3**, a compactly folded stack **20** of strip-chart **13** is held loosely in supply basket **21**. The chart **13** is drawn smoothly and evenly at constant speed from the basket **21** over convex surface **22** by rotation of sprocket teeth **15***a* and **15***b* which engage the series of spaced sprocket holes **16** on each edge of the chart. After leaving the sprocket teeth **15***a* and **15***b*, the chart **13** drops down and the residual memory of each fold of the chart automatically acts to refold it into its original compactly folded stack form, generally indicated at **23**, as it lands in receiving basket **24**. Tension is applied to chart **13** by the combination of biasing mechanism **25** and the wrap of the chart against convex surface **22**. The chart **13** is suspended under tension between the end edge **26** of surface **22** and the surface **27** of chart roll **28**. The recording pens **14***a*–14d are located over the suspended section **29** of chart **13**.

In operation, the biasing mechanism **25** presses the chart firmly against the convex surface **22**. Biasing pressure is applied to insure that the frictional forces resisting movement of the chart are sufficient to draw the chart substantially flat at it suspended section **29**. This frictional force must be less, however, than that required to either remove the memory of the fold or tear the uncut paper remaining across the width of the chart. The frictional force may be established at a desirable value by the selection of suitable biasing springs **30***a* and **30***b* which apply the force at widely spaced points across the chart (as shown particularly in FIG. **4**). By applying the force at such widely spaced points and drawing the chart by sprocket wheels **15***a* and **15***b*, engaging sprocket holes **16** located on each edge of the chart, the chart is maintained accurately in position under tension at the point of recording.

Now turning to FIGS. **4** and **5**, the structure of chart drive unit **10** is more fully shown. The chart drive unit **10** consists of a frame **31** and a cradle assembly **32**. The cradle assembly **32** is pivotally mounted in the frame **31** by pivots **33***a* (not shown) and **33***b* as shown in FIG. **2**. The use of the pivoting feature will be explained later herein.

The frame **31** is formed from a single piece with a back wall **34** welded to tabs **35***a* (not shown) and **35***b* of side walls **36***a* and **36***b* respectively. At the front edge **37** of bottom **38** is formed a receiving basket **24** consisting of horizontal arms **39***a* and **39***b* and vertical fingers **40***a* and **40***b*. At the lower front edge of sides **36***a* and **36***b* are holes **41***a* and **41***b* respectively for receiving pivots **33***a* and **33***b*. Captive screws **97***a* (not shown) and **97***b* are located on the back wall **34** for attaching the frame **31** to a bulk-head (not shown) in the recording apparatus. A pen lifter **42** is attached to ears **43***a* and **43***b* located on sides **36***a* and *b* respectively by screws **44***a* and **44***b*. The pen lifter **42** includes flexures **45***a* and **45***b* which act as pivots for manually lifting the pen lifter as will be described more fully later herein. The upward motion of the pen lifter is limited by engaging finger **46** with stop **47** formed on the upper edge of side wall **36***a*. The pen lifter **42** also includes tabs **48***a* and **48***b*, the purpose of which will be explained later herein.

The cradle assembly **32** consists of the side walls **49***a* and **49***b* welded to a plurality of tabs **50** of the lateral member **51** to provide a rigid frame. A chart drive motor (not shown) is attached to side wall **49***a* by screws **51***a*, **51***b*, and **51***c*. Biasing mechanism **25** consists of a roll **52** having resilient rings **53***a* and **53***b* mounted in widely spaced grooves **54***a* and **54***b* thereon and of arbors **55***a* and **55***b* (not shown) at each end thereof. The biasing mechanism **25** is mounted in lateral contact with the back surface **56** of lateral member **51** with the arbors **55***a* and **55***b* inserted in the journal member **57***a* and **57***b*, respectively and the bosses **58***a* and **58***b* (not shown) of the journal members inserted in slots **59***a* and **59***b* located in side walls **49***a* and **49***b* respectively so that the roller **52** is movable towards and away from surface **56**. Biasing springs **30***a* and **30***b* are hooked at one end to the extension **60***a* and **60** *b* of journal member **57***a* and **57***b* respectively and at the other end to ears **61***a* and **61***b* located on side walls **49***a* and **49***b* respectively.

Chart roll assembly **62** consists of a chart roll **28** at each end of which are integral therewith sprocket teeth **15***a* and **15***b*. A thumb wheel **64** is pressed onto the outer end **63** of chart roll **28** adjacent to sprocket teeth **15***b*. A drive gear **65** is rotatably mounted at the other end of chart roll **28** with the surface of the drive gear **65** in frictional engagement with the end **66** of the roll **28** by turning the threaded end of arbor **67** into the threaded hole **68** of roll **28** with a wave type spring washer **69** between the flange **70** of arbor **67** and the recessed surface **71** of drive gear **65**. The friction between the surface of drive gear **65** and surface **66** is adjusted so that the roll **28** may be rotated manually by using thumb wheel **64** to overcome the friction without otherwise disengaging the chart drive motor. The chart roll assembly **62** is mounted on the upper front of the cradle assembly **32** by pressing bushings **72***a* and **72***b* into holes **73***a* and **73***b* in sides **49***a* and **49** respectively, then inserting the ends of arbor **67** in bushing **72***a* and arbor **74** in hole **73***b* with arbor **74** rotably mounted on

the thumb wheel end 63 of chart roll 28. A spring 75 is inserted between chart roll 28 and arbor 74 to bias the chart roll 28 towards the side 49*a* to eliminate any longitudinal motion thereof and thus insure accurate registration of the chart with respect to the pens 14*a*–14*d*.

Lateral panel 76 is loosely attached to side walls 49*a* and 49*b* by screws 77*a* and 77*b* (not shown) and to ear 78 on lateral member 51 by screw 79 to enable inserting the pivots 80*a* and 80*b* (not shown) of scale holder 81 in holes 82*a* and 82*b* respectively in the front edges of side walls 49*a* and 49*b*. The screws 77*a*, 77*b* and 79 are then tightened. At the upper end of arms 83*a* and 83*b* of scale holder 81 are projecting spherical pins 84*a* and 84*b* (not shown) which, when the scale holder 81 is swung upwardly, engage detents 85*a* (not shown) and 85*b* located on the inner edge of sides 49*a* and 49*b* respectively. At the lower edge of scale holder 81 are a series of chart guide members 86.

As shown best in FIG. 5, lateral member 51 includes arms 87*a* (not shown) and 87*b* which combine with back surface 56 of the lateral member to form supply basket 21. Back surface 56 includes the convex surface 22 for supporting chart 13 to the end 26. Biasing mechanism 25 is located so that the biasing pressure against the chart 13 occurs near the start of the convex surface 22 to provide adequate wrap of the chart 13 against the convex surface 22.

Referring now to FIGS. 4 and 5, the cradle assembly 32 may be swung down about pivots 33*a* and 33*b* by lifting finger 46 of the pen lifter 42 to release tabs 48*a* and 48*b* from engagement with slots 88*a* and 88*b* located on the elevated edges 92*a* and 92*b* of the side walls 36*a* and 36*b* of the cradle assembly 32. By releasing the finger 46 to engage tabs 48*a* and 48*b* with slots 90*a* and 90*b* on the side walls 36*a* and 36*b*, the cradle assembly 32 exposes the screws 97*a* and 97*b* for attaching the chart drive unit 10 to the bulk head (not shown) in the recording apparatus. By releasing the finger 46 and swinging cradle assembly 32 fully down, the cradle assembly 32 is in a favorable position for placing the compactly folded stack 20 of strip-chart into supply basket 21 and threading the chart 13 under biasing mechanism 25 in contact with convex surface 22 and engaging the sprocket holes 16 with sprocket teeth 15*a* and 15*b*. The cradle assembly 32 is returned to its recording position swinging upward and the tabs 48*a* and 48*b* engage with slots 88*a* and 88*b*. When the tabs are engaged with slots 88*a* and 88*b*, the pens 14*a*–14*d* are accurately positioned with respect to the chart. When the pen lifter is raised to release tabs 48*a* and 48*b* from slots 88*a* and 88*b*, the upper surface of edge 91 lifts the pens 14*a*–14*d* out of contact with chart 13 and maintains them out of contact by the tabs 48*a* and 48*b* resting on the elevated edge 92*a* and 92*b* of side walls 36*a* and 36*b*.

As the chart roll 28 is rotating, the chart 13 is allowed to drop off the roll between the front surface 93 of the lateral panel 76 and chart guide members 86 on scale holder 81 and positions it so it will refold as it is received in receiving basket 24 as previously described.

Referring to FIGS. 2 and 4, notches 94*a*–94*d* on finger 46 of pen lifter 42 are provided as gauges for the longitudinal alignment of pens 14*a*–14*d* respectively over suspended section 29 of the chart 13.

As shown particularly in FIG. 2, a scale card 95 having one or more scales thereon is attached to the surface of the scale holder 81 for reading the data traced on the chart. A pen scale 96 is attached to the case 11 for reading the position of pens 14*a*–14*d*. The graduations on chart 13, the scales on scale card 95 and pen scale 96 are suitably aligned.

What is claimed is:

1. A strip-chart recording apparatus for recording the value of a condition on a strip-chart of the type having a series of equally spaced sprocket holes at each side thereof and which is supplied in a compactly folded stack comprising, in combination:
- a supply basket adapted to receive said compactly folded stack,
- a surface aligned with said supply basket to support said strip-chart as it is unfolded from said stack,
- said surface being flat in a direction transverse to the movement of said strip-chart and convex in direction of said movement,
- a chart roll having its axis of rotation aligned parallel to said flat surface and spaced a distance in the direction of said movement from the end of said surface whereby a section of said strip-chart is suspended between said end and the point of contact with said chart roll,
- said chart roll having sprocket teeth at each end thereof adapted to engage said series of equally spaced sprocket holes in said strip-chart.
- means for rotating said chart roll at a uniform speed,
- a tensioning device biased to exert a force between said strip-chart and said surface at a distance from said end whereby said force and the friction of said strip-chart in contact with said convex surface resists the pull of said sprocket teeth as said chart roll rotates, thereby providing sufficient tension to hold the suspended section of said strip-chart in its unfolded condition substantially flat,
- and pen means adapted to record on said suspended section of said strip-chart.

2. A strip-chart recording apparatus in accordance with claim 1 in which the tensioning device comprises:
- A roller in rolling contact with the opposite surface of said strip-chart from said convex surface and is spring biased towards said convex surface.

3. A strip-chart recording apparatus in accordance with claim 2 in which said roller of said tensioning device
- includes two rings in rolling contact at symmetrically spaced apart tranverse points with said strip-chart.

4. A strip-chart recording apparatus in accordance with claim 1 having a receiving basket and
- a guide means under the chart roll aligned to guide said strip-chart after it has passed over said chart roll whereby said strip-chart will reform as it enters said receiving basket into a compactly folded stack.

5. A strip-chart recording apparatus in accordance with claim 1 having a pen lifter means for manually lifting the pen means out of contact with said strip-chart,
- said pen lifter means including a knotched gauge at one side thereof aligned to provide a reference point for accurately adjusting the longitudinal recording point of said pen means along said strip-chart over said suspended section.

* * * * *